Kentucky
Agricultural Experiment Station
University of Kentucky

SOURCES OF ANIMAL PROTEIN FOR LAYING HENS

I. Varying percentages of meat scrap in the mash.

II. A comparison of sour skim-milk, condensed and dried buttermilk with meat scrap.

III. Grain supplements for skim-milk.

BULLETIN NO. 260.

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(99)

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SUMMARY

Part I

1. Meat scrap in the laying mash in any proportion from 5% to 20% is profitable for the production of eggs.
2. A mash containing 20% meat scrap will yield more eggs and more profit than one containing only 5%, 10% or 15% meat scrap.
3. Altho increasing the proportion of meat scrap in the mash increases the feed cost per hen, it also increases the egg yield, thereby decreasing the cost per dozen eggs.

Part II

1. A mash consisting of equal parts by weight of bran, shorts, ground oats and corn meal had no apparent effect in increasing egg production or profits.
2. One gallon of skim-milk had the same value for egg production as one pound of meat scrap.
3. When all the animal protein is supplied from skim-milk or condensed buttermilk, there is no advantage in feeding a dry mash containing ground grains and wheat by-products.
4. When breeding hens receive whole grain and run on a well sodded lot (green food) there is little difference in the hatchability of fertile eggs, whether meat scrap or skim-milk is the source of protein.
5. Both dried buttermilk and condensed buttermilk are efficient commercial sources of animal protein and are desirable for use when skim-milk or buttermilk is not available on the farm.

Part III

1. Shelled yellow corn and skim-milk (no mash) produce very satisfactory egg yields.
2. Wheat is a very desirable addition to the grain mixture if not too high in price.
3. Oats of a low quality (light oats less than 30 lbs. per bushel) increase the fiber in the grain ration and add little to its feed value.
4. It is not necessary to feed a dry mash to secure high egg yields and satisfactory profits if skim-milk is available as a source of protein.
5. Granulated buttermilk may be used to supplement the grain mixture (no mash fed) with very good egg yields, as is indicated by one year's results.
6. Maximum egg yields and greatest returns over feed cost were obtained (one year's data) when a mash containing 10% meat scrap was fed in addition to skim-milk to supplement the grain ration.

BULLETIN NO. 260.

Sources of Animal Protein for Laying Hens

By J. HOLMES MARTIN*

It is a well established fact that maximum egg yields cannot be secured when only the common grains and their by-products are used in the ration. That some source of protein in the form of a protein concentrate is necessary has been shown in previous experiments at this and other Experiment Stations. Tankage, meat scrap, skim-milk, buttermilk and the commercial forms of milk are the most readily available sources of animal protein for egg production.

Since protein concentrates are, with relation to grain prices, always high in price per pound, the question arising in the mind of the poultryman is to what extent can he afford to supplement his poultry ration with these concentrates. The question also arises as to which concentrate to use from among those readily available. It was to aid in answering these problems that the following series of experiments was run.

METHODS USED

All pens in these experiments consisted of March and early April hatched pullets, except in Pens 1A and 3A of Part II B. In this case yearling hens were used because results relative to the hatchability of the eggs were desired. All pens were housed in shed-roof houses of equal size and the same design, except Pens 1A and 3A of Part II B which were in similar half-monitor houses. All pens had the run of lots of equal size and well set in bluegrass sod. Grit and oyster shell were available in all

*The author is indebted to C. L. Morgan, graduate student, for his assistance in computing tables and determining the nutritive ratios.

pens at all times. Where mash was fed it was always availab in a self-feeder. Each pen receiving skim-milk had it availab at all times in a large open pan. Such pens received no drin ing water. Fresh water was always available for the pens r ceiving no skim-milk. All pens received grain morning ar evening in the straw litter.

Accurate trap-nest records were kept. By means of the records the eggs laid by any hens dying before the expiration the first 10 months of the experimental year could be exclude from the average.* In other words the egg yields include on those laid by hens living thru the first 10 months of the exper ment, or on to its conclusion. In computing average feed co sumption, proper adjustment was made for the feed consume by hens which died. Hens failing to lay as many as 10 eggs any one month of their year were treated as abnormal indiv duals and their records excluded from the egg averages.**

In computing the nutritive ratios the figures for digestib nutrients given in Henry and Morrison's "Feed and Feeding were used. Kaupp's digestive coefficient for meat scrap w used in computing its digestible nutrients. The chemical anal sis of the meat scrap used was 50.7% crude protein.

Feed and Egg Prices: The prices of feeds used in the e periment are as follows:

TABLE 1.—PRICES OF THE FEEDS USED.

Corn	$0.84 per bu.
Oats	.52 per bu.
Wheat	1.20 per bu.
Shipstuff	29.00 per ton
Bran	28.00 per ton
Shorts	30.00 per ton
Ground oats	1.62 per cwt.
Corn meal	1.50 per cwt.
Meat scrap	80.00 per ton
Tankage	70.00 per ton
Granulated buttermilk	8.00 per cwt.
Condensed buttermilk	4.00 per cwt.
Skim-milk	.50 per cwt.

*The mortality in all pens was relatively low, averaging only 2 bi per pen (10 per cent) during the year for the Wyandottes.

**There were only five or six such individuals and their external ch acters indicated some internal oviduct trouble.

Egg prices used in computing tables were based on average retail prices of eggs in Lexington during the experiment. They are as follows:

TABLE 2.—PRICES OF EGGS.

November and December	60c per dozen
January	50c per dozen
February	48c per dozen
March thru August	30c per dozen
September	36c per dozen
October	42c per dozen

Part I.

VARYING PERCENTAGES OF MEAT SCRAP IN THE MASH

To determine the best proportion of meat scrap in the mash for laying hens a series of experiments in which four pens of birds were fed five, ten, fifteen and twenty per cent meat scrap in the mash was begun in November, 1918, and conducted for three successive years. The dates of the tests were as follows:

Series 1. November 1, 1918, to October 31, 1919.
Series 2. November 1, 1919, to October 31, 1920.
Series 3. November 1, 1920, to October 31, 1921.

Birds. The birds used in this experiment were White Wyandotte pullets hatched from the Kentucky Experiment Station flock. During the first test 15 birds per pen were used, while in the second and third tests 20 birds per pen were used.

Rations. The grain mixture for all pens was the same thruout the experiment and consisted of corn 70 parts and oats 30 parts. The mash fed the various pens was as follows:

TABLE 3.—COMPOSITION OF THE MASH.

	Pen No. 1	Pen No. 2	Pen No. 3	Pen No. 4
Shipstuff*	47.50 lbs.	45.00 lbs.	42.50 lbs.	40.00 lbs.
Corn meal	23.75 lbs.	22.50 lbs.	21.25 lbs.	20.00 lbs.
Ground oats	23.75 lbs.	22.50 lbs.	21.25 lbs.	20.00 lbs.
Meat scrap	5.00 lbs.	10.00 lbs.	15.00 lbs.	20.00 lbs.

*Essentially equal parts bran and shorts, but not separated at the mill.

In addition to the grain and mash, grit and oyster shell were available in hoppers for the birds at all times. Fresh drinking water was always available.

Results. The yearly egg production, both for the individual years and for the entire period, showed an increase in production with each increase in the amount of meat scrap in the mash. In winter production the results were not so uniform, but on the average, with the exception of the 15 per cent meat scrap pen, the greater amount of meat scrap produced the greater number of winter eggs. The following table shows the winter and yearly egg production per bird for each of the three tests:

TABLE 4.—EGG PRODUCTION PER HEN.

Mash	1918-1919		1919-1920		1920-1921		Ave. 3 Yrs.	
	Winter	Year	Winter	Year	Winter	Year	Winter	Year
5% meat scrap	25.0	118.1	20.5	116.9	18.8	93.3	21.2	108.7
10% meat scrap	29.7	141.6	27.1	129.1	28.4	110.3	28.3	125.5
15% meat scrap	33.6	148.7	26.6	138.3	25.3	116.6	27.9	133.3
20% meat scrap	37.4	157.8	24.7	142.1	31.1	137.0	30.8	145.5

It is interesting to note that the smallest differences in production were found between the 10 per cent meat scrap and the 15 per cent meat scrap pens. Between the 5 per cent meat scrap and the 20 per cent meat scrap pens the differences in winter and yearly production were quite marked.

The pens receiving 10 per cent, 15 per cent and 20 per cent meat scrap in the mash consumed more feed than did the 5 per cent meat scrap pen. The 20 per cent meat scrap pen consumed the greatest amount of grain in proportion to mash, while the 5 per cent meat scrap pen consumed the smallest amount of grain to mash. The 20 per cent meat scrap pen consumed slightly less feed than either the 10 per cent or the 15 per cent meat scrap pens. The nutritive ratio of the rations varied inversely in proportion to the amount of meat scrap in the mash. The following table shows the amounts of feed consumed:

TABLE 5—FEED CONSUMED PER HEN IN POUNDS, AND NUTRITIVE RATIO.

Mash	1918-1919			1919-1920			1920-1921			Ave 3 Yrs.		
	Grain	Mash	N. R.	Grain	Mash	N. R.	Grain	Mash	N. R.	Grain	Mash	N. R.
5% meat scrap	46.9	34.7	1:6.6	48.6	46.1	1:5.3	43.9	25.6	1:6.8	46.4	35.7	1:6.2
10% meat scrap	46.5	34.4	1:6.0	49.4	41.2	1:5.9	54.8	32.1	1:6.3	50.5	36.1	1:6.1
15% meat scrap	47.4	40.2	1:5.3	50.4	49.1	1:5.1	51.5	28.9	1:5.9	50.0	39.7	1:5.5
20% meat scrap	48.8	34.9	1:5.2	50.4	39.1	1:5.0	56.8	26.9	1:5.9	52.2	33.7	1:5.3

In comparing the costs and profits the 20 per cent meat scrap pen showed the greatest feed cost per bird but the least cost per dozen eggs and the greatest profit over feed cost (see Fig. 1). The 5 per cent meat scrap pen was fed at the lowest

Value of Eggs, Feed Cost, and Returns Over Feed Per Hen When Varying Percentages of Meat Scrap are Fed In The Mash

(White Wyandottes)

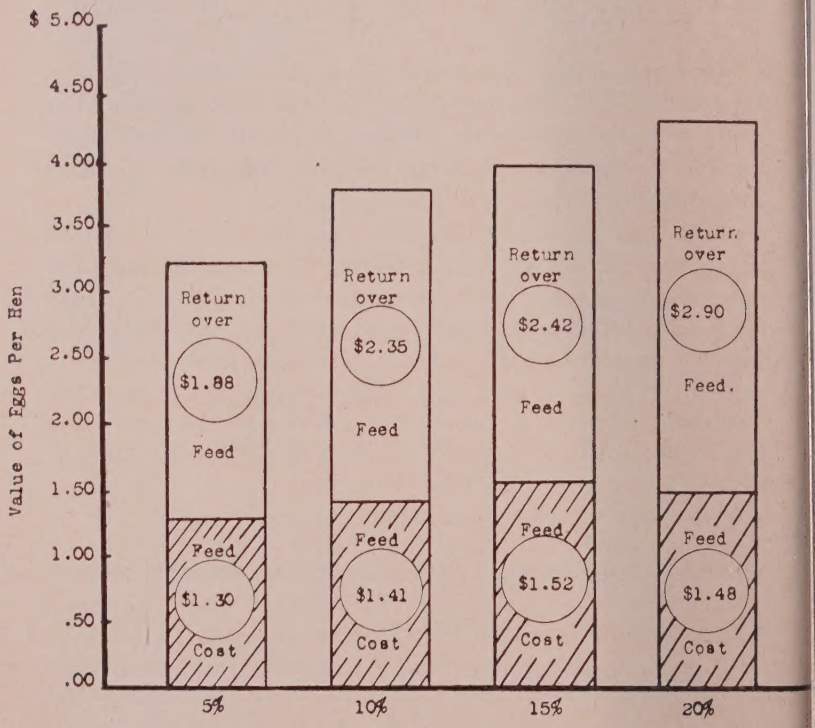

Fig. 1 Percentage of Meat Scrap in Mash.

cost per bird, but the cost per dozen eggs was the greatest and the profits over feed cost the least. The 10 per cent meat scrap and the 15 per cent meat scrap pens, in cost of feed, cost per

dozen eggs and profits over feed cost stood between the 5 per cent meat scrap and the 20 per cent meat scrap pens. In cost per dozen eggs there was scarcely any difference between the 10 per cent and 15 per cent pens but the 15 per cent pen showed the greater profit. The following table shows costs and profits:

TABLE 6.—COSTS AND PROFITS.

Mash	Cost of Feed Per Hen	No. Dozen Eggs	Cost of Eggs Per Doz.	Value of Eggs Per Hen	Profit Over Feed Cost
5% meat scrap	$1.30	9.06	14.3c	$3.18	$1.88
10% meat scrap	1.41	10.45	13.5c	3.76	2.35
15% meat scrap	1.52	11.10	13.6c	3.94	2.42
20% meat scrap	1.48	12.12	12.2c	4.38	2.90

From the standpoint of maintaining the weight of the birds all of the rations were satisfactory. In every trial except one the birds were heavier at the close of the test than at the beginning. The average of the weights thruout the experiment indicated good condition at all times. The following table shows the weights of the birds at the beginning of the test, at the close and an average of all weights taken during the test:

TABLE 7.—AVERAGE WEIGHTS OF HENS. POUNDS.

Mash	1918-1919			1919-1920			1920-1921		
	Begin	End	Ave. (4)	Begin	End	Ave. (5)	Begin	End	Ave. (4)
5% meat scrap....	4.2	4.5	4.5	3.1	4.1	3.9	4.4	4.5	4.5
10% meat scrap....	4.2	4.8	4.6	3.3	4.2	4.3	4.8	4.6	4.7
15% meat scrap....	4.2	4.9	4.7	3.4	4.2	4.3	4.2	4.4	4.5
20% meat scrap....	4.5	5.0	4.8	3.5	4.4	4.4	4.3	4.6	4.6

(5) Average of 5 weights. (4) Average of 4 weights.

Conclusion. Twenty per cent meat scrap in the mash produced both the greatest number of winter eggs and the greatest number of eggs yearly.

The number of eggs produced each year was in direct proportion to the amount of meat scrap in the mash.

As the percentage of meat scrap in the mash increases the cost of feeding a hen for one year tends to increase.

As the percentage of meat scrap in the mash is increased the gross return per hen increases.

The larger the percentage of meat scrap in the mash the greater the profit per hen over feed costs (up to 20%).

TABLE 8.—SUMMARY OF RESULTS.

Grain Plus	Eggs Per Hen		Feed Per Hen		Cost of Feed Per Hen	Cost of Eggs Per Dozen	Gross Return Per Hen	Profit Per Hen Over Feed
	Winter	Year	Grain	Mash				
Mash 5% meat scrap	21.2	108.7	46.4	35.7	$1.30	14.3c	$3.18	$1.88
Mash 10% meat scrap	28.3	125.5	50.5	36.1	1.41	13.5c	3.76	2.35
Mash 15% meat scrap	27.9	133.3	50.0	39.7	1.52	13.6c	3.94	2.42
Mash 20% meat scrap	30.8	145.5	52.2	33.7	1.48	12.2c	4.38	2.90

Part II A

A COMPARISON OF SOUR SKIM-MILK, CONDENSED AND DRIED BUTTERMILK WITH MEAT SCRAP.

Method of Experimentation. To compare the value of sour skim-milk and condensed buttermilk with meat scrap as supplements to a basic mash and to compare the same forms of milk as supplements to grain with no mash a series of tests was begun November 1, 1920, and continued for three years. On November 1, 1921 another pen was added to the test, in which dried buttermilk was used as a supplement to the basic mash. The dates of the tests were as follows:

Series 1. November 1, 1920, to October 31, 1921.
Series 2. November 1, 1921, to October 31, 1922.
Series 3. November 1, 1922, to October 31, 1923.

Stock. The birds used were White Wyandottes of the same breeding as used in Part I. Twenty birds were used in each pen.

Rations. The grain mixture for all pens thruout the experiment consisted of corn 70 parts and oats 30 parts. The various pens received in addition to grain the following mash and milk supplements:

TABLE 9.—FEEDS USED.

Feed	Pen 1	Pen 2	Pen 3	Pen 4	Pen 5	Pen 6
Bran	5 lbs.	5 lbs.	No	5 lbs.	No	5 lbs.
Shorts	5 lbs.	5 lbs.		5 lbs.		5 lbs.
Corn meal	5 lbs.	5 lbs.	Mash	5 lbs.	Mash	5 lbs.
Ground oats	5 lbs.	5 lbs.		5 lbs.		5 lbs.
Meat scrap	5 lbs.					
Dried buttermilk						8 lbs.
Skim-milk		Ad lib.	Ad lib.			
Condensed* buttermilk				1 lb. daily for 16-20 birds	1 lb. daily for 16-20 birds	

*Commonly sold as semi-solid buttermilk.

In addition to the rations stated above, grit and oyster shell were available for the birds, in hoppers, at all times. Fresh drinking water was continually before all birds except those receiving skim-milk in which pens no water was given. In the various mashes used equal amounts of protein were supplied by the protein concentrates. In the skim-milk and condensed buttermilk pens there was no opportunity for controlling the amount of protein the birds received.

Feeding. Mash, where used, was kept in hoppers before the birds at all times. Skim-milk, where used, was supplied *ad libitum* and no water was given. Condensed milk was fed at the rate of one pound daily to 16 to 20 hens, in the paste form, just as it came from the barrel. The grain was fed in the straw litter twice daily.

Results. A comparison of Pens 2 and 3 shows that the addition of the basic mash to a ration of grain and sour skim-milk had no apparent effect in increasing either winter or yearly egg production. In two out of three years the pen which did not receive the basic mash laid more winter eggs than the pen receiving the mash. On the basis of a three year average the pen receiving the basic mash produced 3.3 more winter eggs per hen, but 5.4 fewer eggs per pen for the year. It is evident then that the basic mash which was composed of equal parts of bran, shorts, ground oats and corn meal was of no apparent value in increasing winter or yearly egg production. A similar comparison of Pens 4 and 5 shows that the basic mash, when used to supplement a ration of grain and condensed buttermilk did not result in an increase in egg production. As a matter of fact the pen which did not receive basic mash produced on the average for the three years 2.4 more winter eggs per hen. On the basis of two full years the pen which did not receive the basic mash averaged 5.2 more eggs. Again it is quite evident that the addition of the basic mash to the ration of grain and condensed buttermilk was of no apparent value in increasing either winter or yearly egg production. The pen receiving the mash containing the dried buttermilk (on the basis of two years results) gave the largest number of eggs during both the winter and year. The

pen receiving a basic mash to which meat scrap was added stood last among the six pens in winter egg production (see Figs. 2 and 3). This is probably accounted for by the fact that the addition of milk to the ration of the pullets on November 1st tended to stimulate them into higher winter egg production. Altho the

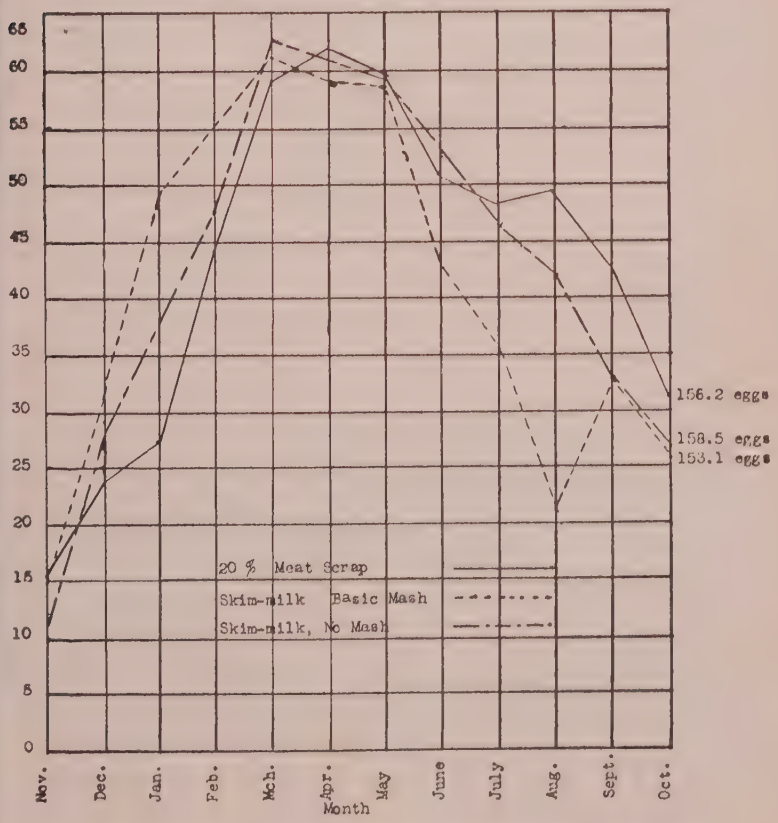

Fig. 2 Distribution of Egg Production in Skim-milk & Meat Scrap Pens.

meat scrap pen stood last on the basis of winter egg production, it stood fourth on the basis of yearly egg production, laying enough eggs during the spring and summer to surpass the skim-milk-mash pen (Pen 2) and the condensed buttermilk-mash pen (Pen 4). The following table shows the production per pen, both for the winter and for the year.

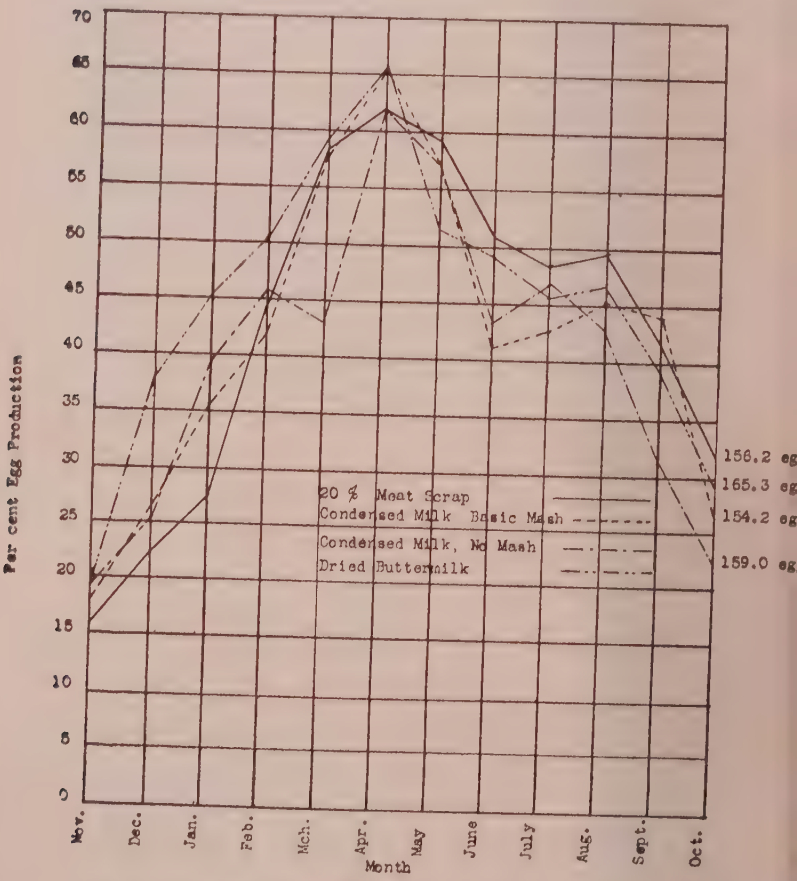

Fig. 3 Distribution of Egg Production in Condensed & Dried Buttermilk Pens.

TABLE 10.—EGG PRODUCTION PER HEN.

Pen	1920-21		1921-22		1922-23		Average	
	Winter	Year	Winter	Year	Winter	Year	Winter	Year
1	31.1	137.0	27.5	150.6	40.0	178.3	32.7	156.2
2	43.7	135.1	38.0	160.8	48.7	163.1	43.6	153.1
3	47.4	157.0	44.7	158.7	30.5	159.7	40.3	158.5
4	33.8	144.8	30.6	101.4*	45.0	163.3	36.4	154.2†
5	40.4	154.0	27.6	87.7*	48.6	164.0	38.8	159.4†
6			48.4	179.0	41.1	149.0	†45.3	165.3†

*8 months production. Due to an infestation of intestinal worms these pens were discontinued after 10 months.
†Two years average.

When skim milk and condensed milk are calculated on the basis of their milk solids and the feed consumption of the various pens compared, it will be noted that the pen receiving condensed buttermilk and no mash (Pen 5) consumed the smallest amount of feed per year and the pen receiving condensed butter-

Fig. 4. Pen 5 (1921-1922) which averaged 154 eggs per hen. The bird marked X laid 242 eggs. This picture was taken immediately after the 12 months test.

milk mash (Pen 4) the largest amount of feed. A comparison of pens 2 and 3 shows that when no mash was fed the total feed consumed was 4.3 pounds less. A comparison of pens 4 and 5 likewise shows that when no mash was fed the total feed consumed

was 1.9 pounds less. In other words in both cases the addition of the basic mash increased the total feed consumption, when milk is calculated on the basis of its solids. That this same point was true with yearling hens is brought out in Table 18 of Part II B. The pens receiving skim-milk—no mash (Pen 3) and condensed buttermilk—no mash (Pen 5) consumed practically the

Fig. 5. Twelve hens from Pen 3A after 2 years on grain and skim-milk (no mash). The birds are arranged from left to right according to their total production for two years, the lowest producers on the left and the highest on the right.

same amount of grain. The following table shows the amounts of feed consumed by the various pens:

TABLE 11.—FEED CONSUMPTION PER HEN, POUNDS.

Pen	1920-21			1921-22			1922-23			Average			Total Feeds with Milk Solids†
	Grain	Mash	Milk	Grain	Mash	Milk	Grain	Mash	Milk	Grain	Mash	Milk	
1	56.8	26.9		48.1	34.4		44.7	32.7		49.9	31.0		80.9
2	47.0	18.9	73.4	53.3	14.4	98.9	46.4	25.1	89.0	48.9	19.5	87.1	77.1
3	60.0		92.6	63.8		94.4	68.4		75.4	64.1		87.5	72.8
4	51.5	17.8	24.1	46.1*	28.5*	17.6*	58.7	21.9	31.8	52.1	22.7	24.5	81.8
5	59.9		20.1	63.2*		14.7*	67.8		32.2	63.6		22.3	69.9
6				45.9	35.4		57.5	22.8		51.2	29.1		80.2

*Calculated for the year on the basis of consumption during 10 months of the test.

†Milk solids in skim-milk, taken from Feeds and Feeding.—Henry & Morrison. Solids in condensed milk, taken from U. S. D. A. Bulletin 1052.

The nutritive ratios of the feed consumed by the various pens are given in the table below. Those of the pens receiving

skim-milk and condensed buttermilk with no mash are the widest. Since these pens are relatively high in egg production it would indicate that milk protein was more available for egg production than the other proteins of the rations.

TABLE 12.—NUTRITIVE RATIOS OF FEED CONSUMED.

Pen	1920-21	1921-22	1922-23	Average
1	1:5.7	1:5.04	1:4.8	1:5.18
2	1:5.88	1:5.58	1:5.5	1:5.65
3	1:5.84	1:6.01	1:6.3	1:6.05
4	1:5.9	1:6.1	1:5.5	1:5.8
5	1:6.5	1:7.1	1:5.8	1:6.5
6		1:5.6	1:5.5	1:5.55

In considering the yearly feed costs per hen in the various pens the lowest feed cost was in the meat scrap-mash pen (Pen 1) closely followed by the skim-milk no mash pen (Pen 3). The profits per hen over feed costs ranked in practically the opposite order from the costs of feed per hen (see Fig. 7.) From a comparison of Pens 1 and 3, when a value of 50 cents per hundred pounds (4.3 cents per gal.) is given to skim-milk, eggs are produced as cheaply as on a meat scrap ration with meat scrap at $4.00 per hundred pounds. Thus it would be fair to give skim-milk a value per gallon equal to the cost of one pound of meat scrap, for the feeding of laying hens.

TABLE 13.—COSTS AND RETURNS PER HEN.

Pen	Cost of Feed Per Hen	Cost of Eggs Per Dozen	Value of Eggs Per Hen	Returns Over Feed Cost Per Hen
1	$1.39	10.5c	$4.82	$3.43
2	1.49	12.0c	4.78	3.29
3	1.42	10.3c	4.84	3.42
4	2.13	17.1c	4.74 (2)	2.61
5	1.87	14.0c	4.94 (2)	3.07
6	1.78	13.0c	5.15 (2)	3.37

(2) 2 years' data only.

From a study of the weights of the birds all rations were satisfactory. All the birds were in good condition (note Fig. 4) thruout the experiment with the exception of Pens 4 and 5 for 1922-23, as already noted. The following table shows the weights of the birds at the beginning and the end of the tests and the average weights during the tests:

Fig. 6. A 200-egg White Wyandotte from Pen 3. This bird laid 173 eggs as a yearling on the same ration in Pen 3A.

TABLE 14.—WEIGHTS PER HEN, POUNDS.

Pen	1920-1			1921-22			1922-23		
	Begin	End	Ave.	Begin	End	Ave.	Begin	End	Ave.
1	4.3	4.7	4.8 (4)	3.5	4.6	4.6 (4)	4.5	5.0	4.9 (3)
2	4.5	4.6	4.7 (4)	3.8	5.3	4.8 (4)	3.9	4.7	4.4 (3)
3	4.2	4.3	4.7 (4)	3.3	4.7	4.6 (4)	4.4	5.0	4.8 (3)
4	3.6	4.5	4.6 (4)	4.5	.....	4.8 (2)	4.1	4.4	4.7 (3)
5	3.9	4.6	4.6 (4)	4.1	.....	4.5 (2)	3.9	4.3	4.3 (3)
6	.....	.....	.....	3.9	4.9	4.8 (3)	4.1	5.0	4.7 (3)

(2) 2 weights. (3) 3 weights. (4) 4 weights.

Value of Eggs, Feed Cost, and Return Over Feed Per Hen When Various Forms of Milk are Used to Supplement Grain With and Without Basic Mash.

(White Wyandottes)

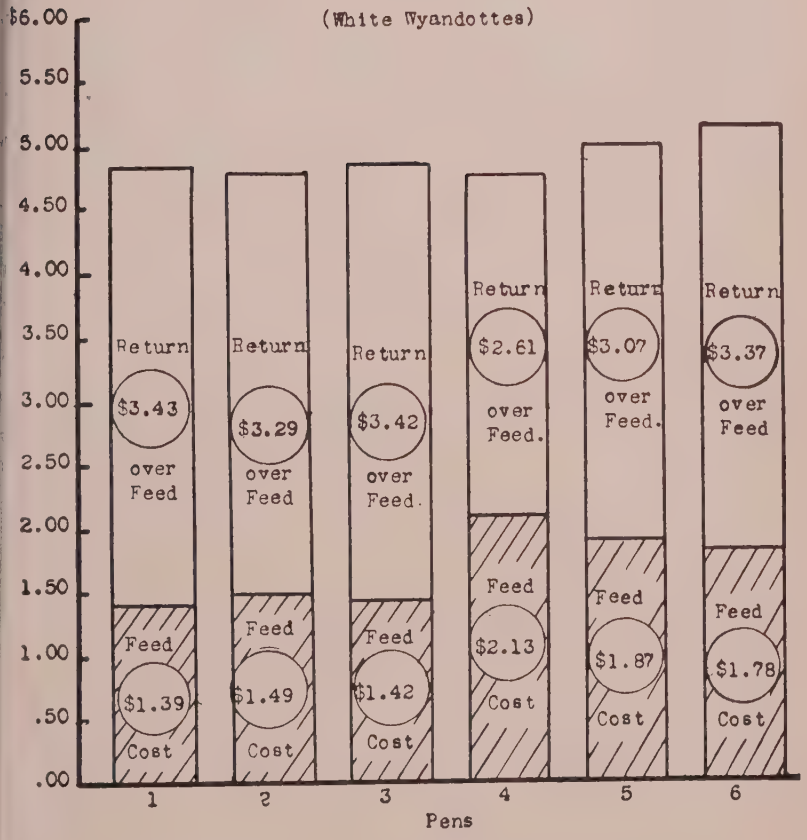

Fig. 7 Forms of Milk for Egg Production.

Pen 1 Grain + Basic Mash + Meat Scrap 20%.
" 2 Grain + Basic Mash + Skim-Milk ad libitum
" 3 Grain + Skim-Milk ad libitum
" 4 Grain + Basic Mash + Condensed Buttermilk
" 5 Grain + Condensed Buttermilk
" 6 Grain + Basic Mash + Dried Buttermilk.

Conclusions. All the rations fed were satisfactory for egg production.

The pen receiving basic mash with dried buttermilk gave the highest production on two years average, producing 165.3 eggs per hen yearly.

There is little value in feeding a dry mash mixture which does not contain any high-protein feed, if liquid milk is being fed as a source of protein.

Very satisfactory egg production can be secured without the use of dry mash if sour skim-milk, liquid buttermilk or condensed buttermilk is available as a source of protein.

If the high-protein feed is omitted from the dry mash, it is of no value for increasing egg production.

The cost of feed per hen was highest in the lots receiving condensed buttermilk. These pens returned the lowest profit per hen over feed costs.

The profit over feed cost per hen was practically equal for the meat scrap—mash and the skim milk—no mash pens. These pens returned profits over feed of $3.43 and $3.42 per hen respectively. These pens gave the greatest profit over feed cost of any of the pens in the experiment.

For egg production one gallon of milk was equal to one pound of meat scrap.

TABLE 15.—SUMMARY OF RESULTS.

Pen	Eggs Per Hen		Feed Per Hen			Cost of Feed Per Hen	Cost of Eggs Per Dozen	Value of Eggs Per Hen	Return Per Hen Over Feed
	Winter	Year	Grain	Mash	Milk				
1	32.7	156.2	49.9	31	.....	$1.39	10.5c	$4.82	$3.43
2	43.6	153.1	48.9	19.5	10.1 gal.	1.49	12.0c	4.78	3.29
3	40.3	158.5	64.1	.....	10.2 gal.	1.42	10.3c	4.84	3.42
4	36.4	154.2*	52.1	22.7	24.5 lbs.	2.13	17.1c	4.74*	2.61
5	38.8	159.0*	63.6	.....	22.3 lbs.	1.87	14.0c	4.94*	3.07
6	45.3*	165.3	51.2	29.1	.....	1.78	13.0c	5.15*	3.37

*Two years' average.

Part II B

HATCHABILITY AND EGG PRODUCTION OF YEARLINGS, WITH AND WITHOUT DRY MASH.

Method of Experimentation. In order to compare the rations used in Pens 1 and 3 of Part II A, 12 breeders from each pen were saved over from the previous year's experiments and continued on the same ration the second year. The dates of the tests of yearling hens were as follows:

Series 1. November 1, 1921, to October 31, 1922.
Series 2. November 1, 1922, to October 31, 1923.

Stock. The birds in Series 1 above were some of those in Series 1 of Part II A. Likewise the birds in Series 2 above were some of those in Series 2 of Part II A. Each pen consisted of the 12 highest record yearling hens remaining in the pens at the close of the pullet year. A White Wyandotte cockerel was kept in each pen thruout the experimental year. These males were alternated during the breeding season, when eggs were being saved for hatching, in order to eliminate any possible influence of the individual males.

Rations. The rations fed were identical with those received by the pens during their pullet year. Pen 1A received the same ration that it had received as Pen 1 the first year and Pen 3A received the same ration that it had received as Pen 3 the first year (see Table 9).

Results: In both winter and yearly egg production the yearlings agreed quite closely with the pullets. Altho the yearling production was, of course, not up to that of the pullet year, nevertheless, the same proportion held true in most cases. Table 16 shows that the yearlings receiving skim-milk held up slightly better in winter egg production, altho not laying quite as well during the entire year as those receiving the mash containing meat scrap.

TABLE 16.—EGG PRODUCTION PER HEN (YEARLINGS).

Pen	1921-22		1922-23		Average	
	Winter	Year	Winter	Year	Winter	Year
1A Mash with meat scrap	22.3	122	25.8	127	24	125
3A Skim-milk only	30.8	120	26	117.3	28	119

Since all the birds kept thru the second year were trap-nested, both as pullets and as yearlings, their egg production for each year may be compared. Table 17 shows that the pullets receiving skim-milk (no mash), altho laying better as pullets, showed a more decided drop than those receiving the meat scrap mash. A comparison of the total number of eggs laid by the birds kept thruout the entire two years, brings out that altho the birds on skim-milk showed more of a drop, they layed a larger number of eggs during the two years than the birds receiving the mash containing meat scrap (see Figs. 5 and 6).

TABLE 17.—COMPARISON OF PULLET AND YEARLING RECORDS

Pen	1921-22		1922-23		Total 2 Years	
	Pullet Year*	Second Year	Pullet Year*	Second Year	1921-22	1922-23
1A Mash	136	122	155.8	127	258	282.8
3A Skim-milk	156.7	120	166	117.3	276.7	283.3

*Actual trap nest records of hens saved over for second year.

The feed consumption for the yearling hens was slightly greater per hen on the average than for the same birds as pullets (compare tables 18 and 11). It is interesting to note, however, that the yearlings consumed an average of 67.4 pounds of skim-milk each, whereas the same pens, as pullets, averaged to consume 93.5 pounds each. The yearlings receiving dry mash averaged to consume 32.9 pounds each, whereas, the same pens as pullets averaged to consume 30.7 pounds each, which shows a slight increase in mash consumption in the yearling year.

TABLE 18.—FEED CONSUMPTION PER HEN.

Pen	1921-22			1922-23			Average		
	Grain Lbs.	Mash Lbs.	Milk Lbs.	Grain Lbs.	Mash Lbs.	Milk Lbs.	Grain Lbs.	Mash Lbs.	Milk
1A Mash	53.3	31.5	.....	56.3	34.4	.....	54.8	32.9	.....
3A Milk	70.6	.....	64.1	73.8	.....	70.8	72.2	.....	67.3

A comparison of the nutritive ratios of Pens 1A and 3A shows that the yearling hens receiving skim-milk (no mash) in each instance received a wider nutritive ratio than those receiving the mash containing meat scrap. Since the former pen produced more eggs, while at the same time receiving a smaller proportion of protein, the point previously made, namely, that milk protein is more available and digestible than meat scrap protein, is again borne out. A comparison of tables 12 and 19 shows relatively little difference between the nutritive ratios for the pullets and yearlings receiving the mash containing meat scrap (Pens 1 and 1A). However, it should be noted that the yearlings receiving the skim-milk (no mash) received a much wider nutritive ratio each year than the same pens did as pullets. This is, of course, due to the fact that they consumed less milk as yearlings and ate more grain the second year. A study of the weights of the yearlings in both pens shows that they remained in good condition thruout the experiment, the birds in the mash pen, however, attained about one-half pound greater maximum weight during the spring of the year than those in the milk pen.

TABLE 19.—NUTRITIVE RATIOS AND BODY WEIGHTS.

Pen	N. R. of Feed Consumed			Average Weights Pounds		
	1921-22	1922-23	Average	Start	Mid-Year	End
1A Mash ..	1:5.33	1:5.2	1:5.27	3.85	5.7	5.2
3A Milk ..	1:6.74	1:6.8	1:6.77	4.55	5.25	5.2

A comparison of the hatchability of the fertile eggs from Pens 1A and 3A shows that there is relatively little difference, if any, between the hatchability of eggs of yearling hens in the two pens. The eggs from each pen were set at the same time and in the same incubator. That more eggs were set from one pen than from the other is because one pen was laying better than the other during the hatching season. Before any eggs were selected for hatching the birds had been receiving the ration under consideration for the previous 16 months, that is, from November first of their pullet year until March first of their yearling year. Table 20 shows no significance in the distribution of embryo mortality before or after the 18th day. The term "dead germs" is used to designate those eggs in which the embryo started development, but died prior to the 18th day. The term "dead in shell" designates those eggs in which the embryo lived beyond the 18th day, but failed to hatch.

TABLE 20.—HATCHABILITY OF FERTILE EGGS.

	Fertile Eggs		Dead Germs		Dead in Shell		Chicks	
	Mash-Pen	Milk-Pen	Mash-Pen	Milk-Pen	Mash-Pen	Milk-Pen	Mash-Pen	Milk-Pen
1922	127	226	20	37	31	60	76	129
1923	125	93	19	15	37	27	69	51
Total	252	319	39	52	68	87	145	180

A percentage comparison of the hatchability of fertile eggs shows that eggs from the mash-fed pen hatched slightly better each year than those from the milk fed pen. However, the difference is so little in favor of the first pen, especially on a two-year average (1.1 per cent) that it may safely be stated that the eggs hatched equally well from one pen as from the other. From the percentages in Table 21 it may be concluded that continuous feeding of a ration of grain and skim-milk (no mash) has no

effect, either harmful or beneficial, on the hatchability of fertile eggs, as compared with the pens receiving grain and a mash containing 20 per cent meat scrap.

TABLE 21.—HATCHABLILITY OF FERTILE EGGS

	Mash Pen	Milk Pen
1922	59.8%	57.1%
1923	55.2%	54.8%
Two years	57.5%	56.4%

Conclusions: Yearling hens on a ration consisting of grain and skim-milk (no mash) produced more winter eggs, but slightly fewer eggs during the entire year, than the hens receiving a mash containing 20 per cent meat scrap.

Yearling hens receiving grain and skim-milk showed more of a drop from their pullet to yearling production than the birds receiving the mash containing meat scrap. However, the former produced more eggs as pullets and during the two years.

When sour skim-milk was fed in place of a dry mash, no apparent effect was noticed on the hatchability of fertile eggs.

Part III.

GRAIN SUPPLEMENTS FOR SKIM-MILK.

Method of Experimentation. To compare the value of corn alone, corn and oats, corn and wheat, and corn oats and wheat as grain mixtures for laying hens, when supplemented with skim-milk, a series of tests was begun November 1, 1922. These tests have been conducted for two years,* which dates are as follows:

Series 1. November 1, 1922, to October 31, 1923.
Series 2. November 1, 1923, to October 31, 1924.

During the second year two more pens were added in which corn and wheat were fed as the grain, with granulated buttermilk** as the supplement, in one pen, and a 10 per cent tankage mash plus skim-milk as the supplement, in the other pen.

Stock. The birds used in these tests were Barred Plymouth Rocks hatched from the flocks at the poultry farm of the Experiment Station. Twenty pullets were used in each pen.

Rations. The rations for the various pens were as follows:

TABLE 22.—FEEDS USED.

Pens	Grain	Supplement
14	Corn alone (shelled)	Sour skim-milk
15	Corn 70%, Oats 30%	Sour skim-milk
16	Corn 70%, Wheat 30%	Sour skim-milk
17	Corn 60%, Oats 20%, Wheat 20%	Sour skim-milk
18	Corn 70%, Wheat 30%	Granulated buttermilk
19	Corn 70%, Wheat 30%	Mash: Bran 40%, Shorts 40%, Corn meal 10%, Tankage 10%; Skim-milk.

Grit and oyster shell were kept before all pens at all times. Drinking-water was furnished to the pen receiving granulated buttermilk (Pen 18).

*The third year of the series is now under way.

**The granulated buttermilk used was obtained from the Collis Products Co., Clinton, Iowa. It is of the same composition as the powdered buttermilk but of a granular form, the granules being slightly smaller than wheat grains.

Feeding. Sour skim-milk was fed *ad libitum* in all lots where it was used. No water was given to the pens receiving skim-milk. Granulated buttermilk was fed at the rate of one pound daily to 20 hens. The mash in Pen 19 was hopper fed and kept before the birds at all times.

Results. In egg production the pens receiving wheat in the grain ration produced the largest number of eggs during both the winter and the year. The highest producing pen (both for the winter and year) receiving skim-milk alone as a supplement was the one receiving corn and wheat for grain (Pen 16). A comparison of Pen 15, which received oats in addition to the shelled corn, with Pen 14, which received only the shelled corn, shows that in winter egg production the pen receiving shelled corn and oats outlayed the other pen in both cases. However, a comparison of the yearly egg production shows that the corn pen laid better the first year than the pen receiving corn and oats, whereas the second year the corn and oats pen outlayed the pen receiving only shelled corn. Better results were secured with oats the second year because the oats used were of a better grade (heavier) than those used the first year. A comparison of pens 16 and 17 shows that the addition of oats to a grain mixture of corn and wheat resulted the first year in a decrease of winter egg production, again probably due to the poor quality of oats. The second year there was practically no difference between these two pens during either the winter or yearly egg production, again bearing out the point that when oats of a good quality were used better results were secured. On the basis of one year's results, a grain ration of corn and wheat supplemented with granulated buttermilk gave the greatest winter production but did not equal in yearly production the other pens receiving wheat in the grain mixture. One year's data showed that a grain mixture of corn and wheat when supplemented with a 10 per cent tankage mash and skim-milk gave the greatest yearly production and good winter production. The following table shows the winter and yearly production per hen:

TABLE 23.—EGG PRODUCTION PER HEN.

Pen	1922-23		1923-24		Average	
	Winter	Year	Winter	Year	Winter	Year
14	60.6	183.1	29.5*	143.3	50	159
15	63.7	165.2	50.7	161.1	56	164
16	76.5	180.9	54.5	168.0	66	178
17	66.5	185.3	54.1	166.7	61	175
18	.....	.....	67.6	167.8	68	168
19	.....	.....	58.7	196.7	59	197

*An epidemic of pox in this pen cut down the November and December production.

In feed consumption, comparing the four pens receiving skim-milk alone as a supplement, the pens receiving wheat as a part of the grain, required less total pounds of feed, when computing the skim-milk as reduced to the basis of milk solids. Oats added to corn as the grain ration increased the total pounds of feed consumed, no doubt due to the higher fiber content of oats. Pen 19 (one year's data) receiving corn and wheat in the grain ration with a 10 per cent tankage mash plus skim-milk required the same number of pounds of feed as the corn-oats-skim-milk pen. The granulated buttermilk pen (one year's data) consumed practically the same amount of feed (milk calculated as solids) as the pen receiving skim-milk, when the same grain ration was fed. The following table shows the feed consumed by the various pens:

TABLE 24.—FEED CONSUMED PER HEN.

Pen	1922-23			1923-24			Average			Total Feeds Including Milk Solids, Lbs.
	Grain, Lbs.	Mash	Milk, Gal.	Grain, Lbs.	Mash	Milk, Gal.	Grain, Lbs.	Mash	Milk, Gal.	
14	70.3	.....	12.8	71.6	.....	14.6	71.0	.....	14	79.9
15	75.4	.....	13.1	74.2	.....	18.3	75.0	.....	16	85.2
16	73.0	.....	13.9	66.7	.....	14.4	70.0	.....	14	78.9
17	72.6	.....	12.3	62.8	.....	17.0	68.0	.....	15	77.5
18	.....	.....	.....	64.2	.....	14.9	64.0	.....	*15	77.9
19	.....	.....	.....	59.2	16.2	16.1	59.0	.....	16	85.2

*Lbs. of granulated buttermilk.

From a study of feed consumed, it is noted that the nutritive ratios of the pens receiving skim-milk alone were practically

the same. The granulated buttermilk pen (pen 18) showed the widest nutritive ratio, while the 10 per cent tankage mash-skim-milk pen (pen 19) had the narrowest nutritive ratio. The following table shows the nutritive ratios calculated on the basis of the feed consumed:

TABLE 25.—NUTRITIVE RATIOS.

Pens	1922-23	1923-24	Average
14	1:6.5	1:5.4	1:5.9
15	1:5.9	1:5.2	1:5.5
16	1:6.1	1:5.7	1:5.9
17	1:5.9	1:5.1	1:5.5
18	.....	1:6.2	1:6.2
19	.....	1:3.6	1:3.6

The feed costs per hen showed that for the four pens receiving skim-milk as the only supplement, the rations containing oats were the most expensive to feed. These same pens also returned the smallest profit per hen over feed cost. The greatest profit per hen over feed costs (see Fig. 9) was from the pen fed corn and wheat as the grain ration. This pen also ranked second in low cost of feeding a hen for one year. The greatest profit was obtained from Pen 19 (one year's data) using a 10 per cent tankage mash and skim-milk to supplement a grain ration of corn and wheat. The pen receiving granulated buttermilk (one year's data) as a supplement to corn and wheat showed the greatest feed cost and the smallest profit over feed cost per hen. The following table shows the value of eggs per hen, cost of feeds per hen, cost per dozen eggs and return or profit over feed cost per hen:

TABLE 26.—COSTS AND RETURNS PER HEN.

Pen	Cost of Feed	Cost of Eggs Per Doz.	Value of Eggs	Profit Over Feed
14	$1.67	12.2c	$5.27	$3.60
15	1.83	13.4c	5.36	3.53
16	1.76	12.6c	5.79	4.03
17	2.14	11.9c	5.72	3.58
18	2.18	16.1c	5.64	3.46
19	1.94	11.2c	6.24	4.30

The weights of the birds show that all rations were quite satisfactory. In all pens the birds gained in weight thruout the experiment (see Fig. 8). The following table shows the weights at the beginning and at the end and the average of weights during the test:

TABLE 27.—WEIGHT OF HENS, POUNDS.

Pen	1922-23			1923-24		
	Begin	End	Ave. (3)	Begin	End	Ave. (3)
14	4.9	5.9	5.5	4.9	6.3	5.7
15	4.8	5.8	5.6	4.8	6.5	5.8
16	5.0	5.7	5.7	4.3	5.6	5.2
17	4.6	5.7	5.3	4.4	5.6	5.3
18				4.9	6.1	5.7
19				4.6	5.7	5.4

(3) Average of 3 weights.

Conclusions. Corn alone with skim-milk was a satisfactory ration for egg production.

Wheat in rations for laying hens reduced the amount of feed consumed (calculating milk on the basis of its solids) and returned a profit over feed cost, in comparable pens, equal to or greater than that of pens receiving no wheat.

Oats in the grain ration for laying hens increased feed costs and reduced the profits over feed cost per hen. This was strikingly brought out in the case of oats of low quality.

Granulated buttermilk (one year's data) increased the cost of feeding a hen per year and did not show as much profit over feed cost as skim-milk.

A 10 per cent tankage mash plus skim-milk (one year's data) furnished the most profitable supplement for a grain mixture of corn and wheat.

A balanced ration is not necessarily a complicated ration, since very satisfactory egg yields can be secured from a ration consisting of shelled corn, sour skim-milk and oyster shell.

Plymouth Rocks receiving only shelled corn for grain and no mash, but with sour skim-milk always available continue in production thruout most of the year and do not tend to get overfat.

A ration containing in addition to the grain mixture, a mash (10% tankage) and all the milk that the flock will consume, will give maximum results.

Fig. 8. Thirteen hens from Pen 14 which were saved over as breeders. This picture was taken the week after they had completed the year's record on corn and skim-milk. The entire pen averaged 183 eggs per hen.

TABLE 28.—SUMMARY OF RESULTS.

Pen	Eggs Per Hen		Feed Per Hen			Cost of Feed Per Hen	Cost of Eggs Per Dozen	Value of Eggs Per Hen	Profits Per Hen Over Feed
	Winter	Year	Grain	Mash	Milk				
14	50	165	71.0	.....	14 gal.	$1.67	12.2c	$5.27	$3.60
15	56	166	75.0	.....	16 gal.	1.83	13.4c	5.36	3.53
16	66	177	70.0	.....	14 gal.	1.76	12.6c	5.79	4.03
17	61	175	68.0	.....	15 gal.	2.14	11.9c	5.72	3.58
18	68(1)	168(1)	64.0	.....	15 gal.	2.18	16.1c	5.64	3.46
19	59(1)	197(1)	59.0	16	16 gal.	1.94	11.2c	6.24	4.30

(1) One year of results.

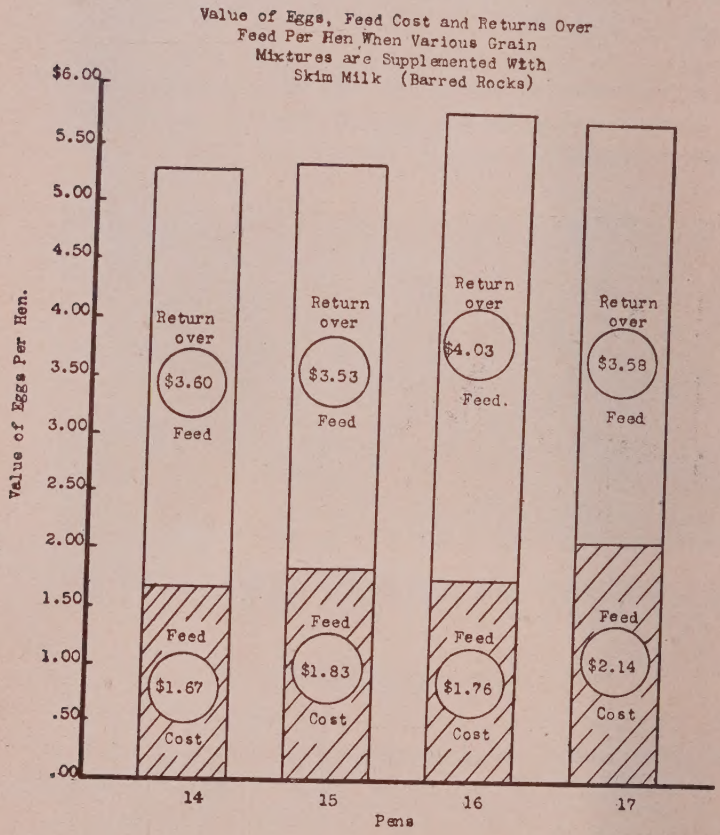

Fig. 9 Grain Mixtures for Egg Production.

Pen 14 Grain + Corn Alone + Skim-Milk Ad Libitum
Pen 15 Grain + Corn 70% Oats 30% + Skim-Milk Ad Libitum
Pen 16 Grain + Corn 70% Wheat 30% + Skim-Milk Ad Libitum
Pen 17 Grain + Corn 60% Oats 20% Wheat 20% + Skim-Milk Ad Libitum